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(58) Field of search
F1B
Selected US specifications from IPC sub-class F02M

(54) **I.c. engine fuel injection valve**

(57) A valve needle (3) which opens inwards counter to the force of a spring (16) has a conical seat surface (4) cooperating with a valve seat (5) in the nozzle body (2) upstream of the spray duct (7). Fuel passages (14) defined in an insert (11) fixed in the nozzle body (2) have their opening cross-sections controlled by the needle (3) as a function of needle lift. Angled insert grooves (13) cause a rotation component in fuel flowing to the spray duct (7). The spray duct and the end of the nozzle body projecting into the engine combustion chamber (8) may take various forms (Figs. 2 to 7).

Fig. 1

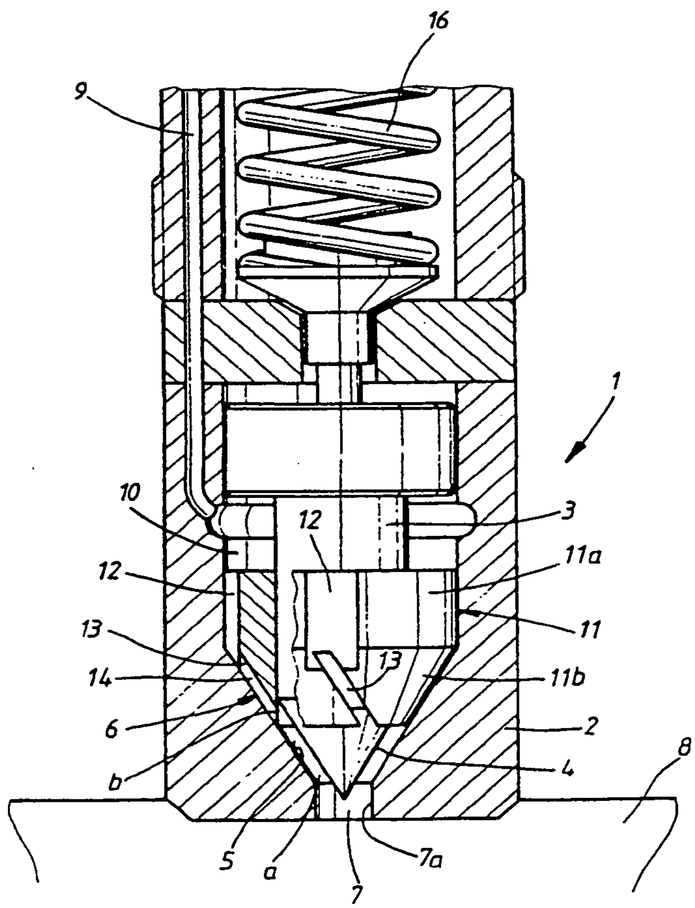

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Fig. 1

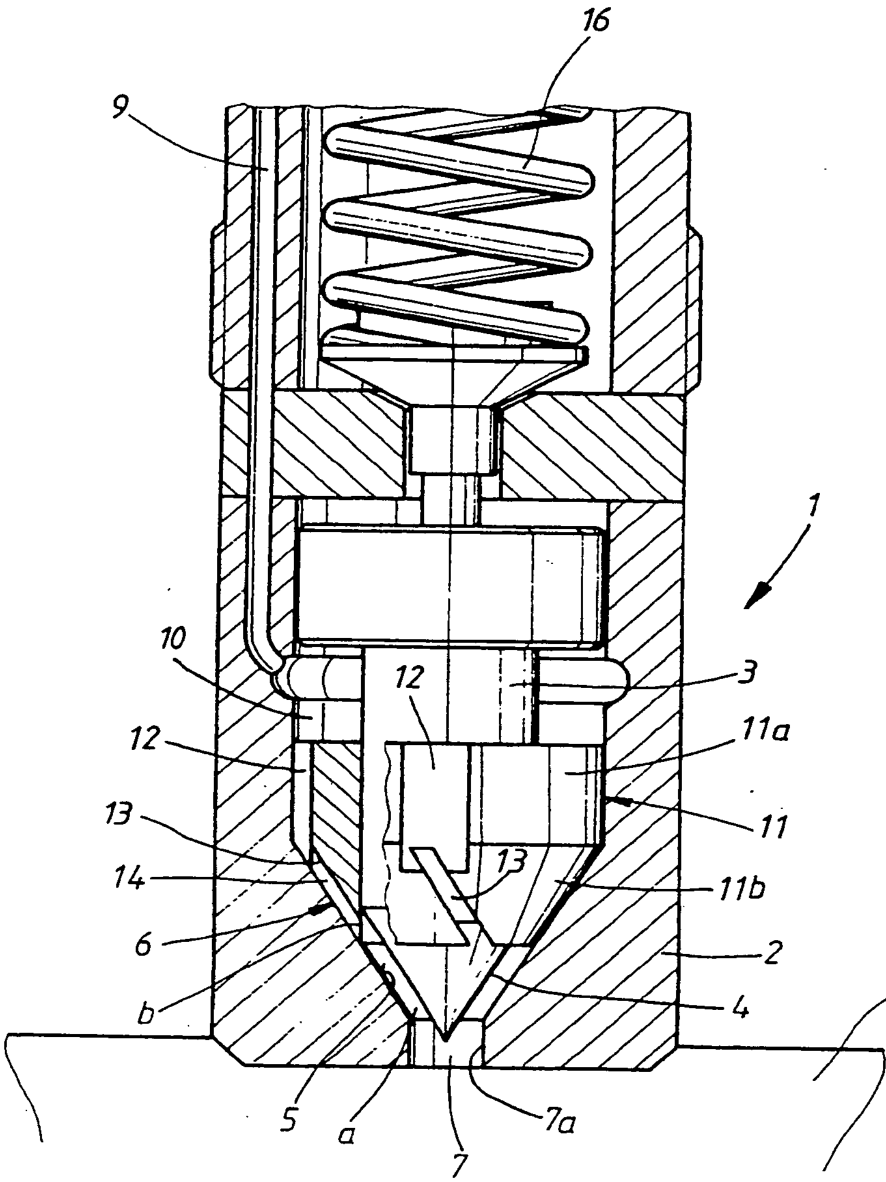


Fig. 2

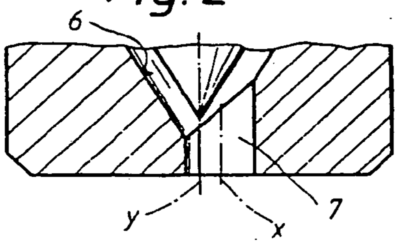


Fig. 3

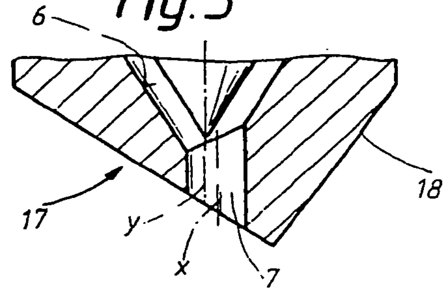


Fig. 4

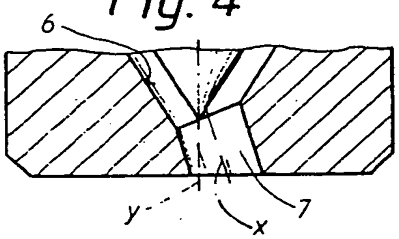


Fig. 5

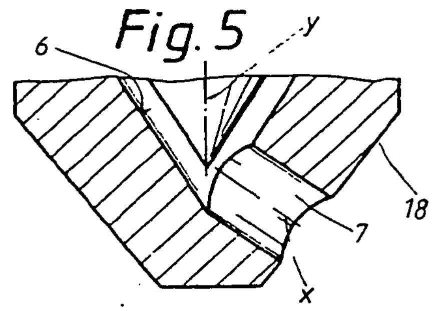


Fig. 6

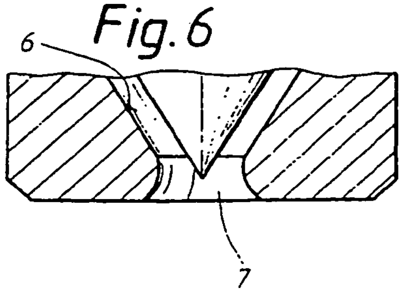
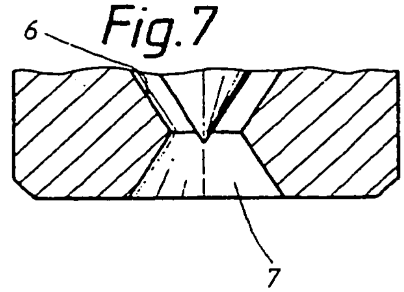


Fig. 7



SPECIFICATION

A fuel injection valve

The invention relates to a fuel injection valve for a fuel-injected internal-combustion engine, particularly an air-compressing engine.

In a fuel injection valve which is known from German Offenlegungsschrift No 3,412,516, a pintle which opens inwards closes a duct which is constructed as a blind hole and communicates with the combustion space of the internal-combustion engine through spray holes present in the nozzle hood.

The pressure difference between spray hole entry and spray hole exit is decisive as a significant parameter for the atomisation quality of this fuel valve, which is constructed as a multi-hole nozzle. When starting and in the lower speed range of the internal-combustion engine, the pressure wave coming from the injection pump is small and insufficient for the complete opening of the pintle, so that a part of the pressure amplitude, which is small in any case, is reduced further in the valve seat region, so that atomisation occurs under unfavourable conditions.

In the fully opened stage the multi-hole nozzle has a constant opening cross-section determined by the size of the spray holes, and therefore an atomisation quality which is a function of throughput, which although adequate at the rated power point, produces poor atomisation in the speed range located below this point.

A fuel injection valve is also known from Swiss Patent No 632,053, in which the pintle which is raisable inwards from its conical sealing seat by the pressure of the fuel fed is deformed so that the pintle dips into the spray hole oriented at an acute angle to the pintle longitudinal axis, whilst the free cross-section at the spray hole is smaller, in every position of the axially slidable pintle, than the respective free cross-section at the sealing seat. Although this causes a fuel pressure to be built up in front of the spray hole already during the opening phase and closing phase of the pintle, whereby a good mixture formation and combustion is intended to be achieved in these phases, nevertheless the association of the spray hole towards the valve seat produces the disadvantage that the fuel flow paths or streams meet at the valve tip and then finally enter the combustion space with wall contact at the spray hole. The result is an impairment of the atomisation quality.

The underlying aim of the invention is to eliminate the disadvantages and to construct the nozzle of a fuel injection valve so that, downstream of the valve seat, a virtually unobstructed injection of fuel into the combustion space can be ensured and, at the same time, an improved atomisation extending into the combustion space can be achieved in the entire range of operation of the internal-combustion engine.

According to the invention, there is provided a fuel injection valve for a fuel-injected internal-combustion engine, having a pintle which is guided in a nozzle element, and has a conical seat surface cooperating with a valve seat formed by a valve cone in the nozzle element, the pintle lifting from the valve seat counter to the force of a spring and counter to the fuel flow direction, the pintle tip simultaneously opening at least one spray passage leading to the combustion space of the internal-combustion engine and the opening cross-section of which is controllable as a function of the pintle stroke, wherein the or each spray passage is arranged in a part of the valve cone located upstream of the valve seat and forms an angle with the envelope line of the valve cone, and a duct located downstream of the valve cone is constructed as a passage duct of large cross-section, through which fuel is delivered unthrottled into the combustion space.

Due to the fact that the opening cross-section of the spray passage or passages located upstream of the valve seat is continuously variable by the pintle stroke and is adaptable to the fuel throughput, the injection nozzle changes its hydraulic behaviour fundamentally.

The pressure which is decisive for the atomisation is composed additively of pressure amplitudes of the forward wave coming from the injection pump and of the return wave reflected from the nozzle. The pintle opens sufficiently until the described sum pressure corresponds to the opening pressure of the nozzle. By an appropriate choice of the nozzle opening pressure, the atomisation quality is therefore determined in the construction according to the invention, whilst the incoming pressure wave determines only the throughput.

Due to the fact that the or each spray passage forms an angle with the envelope line of the valve cone, it is impossible for the injection jets exiting from the pintle seat of the nozzle to collide in the imaginary valve cone tip and therefore to continue as a single jet in the axial direction, which would lead to an unfavourable fuel distribution in the combustion space.

On the contrary, the fuel jets develop umbrella fashion and pass into the combustion space in this manner. The fuel jets pass unobstructed into the combustion space through the duct arranged downstream of the spray passage or passages, as a passage duct of large crosssection.

For technical production reasons, the or each spray passage may be formed as grooves in an insert element resting immovably upon the valve cone of the nozzle element, which has an upper cylindrical part with feed ducts which are adjoined by the respec-

tive spray passage located in the lower conical part.

In order to permit directionally oriented throughputs and to obtain a non-uniform mass distribution for complex combustion space shapes, in case of conical valve seats in the nozzle element, the axis of the valve cone may be arranged so as to be offset relative to the axis of the passage duct and the passage duct leads out at the nozzle end which is of plane construction.

In order to permit an influence to be exerted not only upon the mass distribution of the emergent fuel jets, but also upon their exit direction, in the case of a nozzle element, the asymmetrical nozzle end of which is conically constructed, the passage duct is arranged to be relatively offset and leads out at the larger cone surface of this nozzle end. However, the passage duct may also be arranged with its axis inclined relative to the valve cone axis, whilst the passage duct leads out at the nozzle end which is of plane construction.

In the case where an oblique nozzle position is required because of spatial considerations, the passage duct may be arranged to be so inclined that it leads out at the cone surface of the nozzle end which is of frustoconical construction. Emergent fuel jets are therefore deflected directionally behind the valve seat.

Resulting from the particular positions and configurations of the passage ducts, favourable adaptations of the jet direction of the fuel jets exiting from the nozzle to combustion space shapes of varying construction are obtained.

In the case of certain passage ducts, the fuel jets follow the duct wall contour at first and then pass out of the duct at varying exiting angles due to the end of the passage duct being obliquely sectioned.

In order to achieve the greatest possible jet exit angles without prejudicing the strength of the nozzle tip, the contour of the passage duct is a hyperboloid of rotation so that exiting fuel jets have no further duct wall contact after leaving the pintle seat. The passage duct may however also be of conical construction.

Embodiments of the invention will now be described more fully by way of example and with reference to the accompanying drawings, in which:

Figure 1 shows a longitudinal section through a fuel injection valve, a part of the insert element being shown in elevation in the nozzle region without the nozzle element surrounding it, and particularly the position of the spray hole, and

Figures 2 to 7 show various positions and shapes of the passage duct.

The fuel injection valve 1 for an air-compressing direct fuel-injection internal-combustion engine shown in Figure 1 consists of a nozzle element 2, in which a longitudinally displaceable pintle 3 is guided with longitudinal sliding mobility and the pintle tip 4 of which rests as a conical seat surface upon a valve seat 5 as part of the valve cone 6 in the nozzle element 2.

In the illustrated position of the pintle, a duct 7 is arranged downstream of the pintle tip 4 as a passage duct with unthrottled cross-section leading out into the combustion space 8 of the internal-combustion engine.

The pintle 3 limits a pressure space 10 which communicates with a feed duct 9, and into which an insert element 11 is inserted so that its upper cylindrical element part lla can be connected to the nozzle element 2 for example by pressing or screwing, and the lower, conically constructed element part 11b rests with the whole of its surface on the valve cone 6.

The insert element 11 is provided, in its cylindrical element part 11a, with ducts 12 which are adjoined by grooves 13 arranged in the conically constructed element part 11b, which form conjointly with the nozzle element wall in the region of the valve cone 6, spray passages 14 which extend to the pintle 3 and are therefore located upstream of the valve seat 5. The orientation of the spray passage 14 is such that they form an angle with the envelope line of the valve cone 6 (Figure 1). The passage cross-section of these spray passages 14 is substantially smaller than the passage cross-section of the ducts 12 in the upper element part 11a.

In the fuel injection valve 1 the fuel passes into the feed duct 9 and pressure space 10 and thus into the ducts 12 and spray passages 14. The pintle 3 opens by the fuel pressure applied to its pressure shoulder 15, namely sufficiently until the sum pressure resulting from the forward wave and reflected return wave corresponds to the opening pressure of the nozzle. In this context the spray cross-sections designated "a" in Figure 1 and a spring 16 engaging the rear side of the pintle are tuned for constant pressure in the pressure space so that the opening cross-sections "b" of the spray passages 14 on the outlet side are modified continuously by the pintle stroke and adapted to the fuel throughput.

The fuel jets exiting from the spray passages 14 extend into the combustion space 8 due to the construction of the passage duct 7.

In Figure 1 the passage duct 7 is located coaxially to the pintle 3, whereas in Figures 2 and 3 the axis "x" of the passage duct 7 is offset relative to the axis "y" of the valve cone 6. The passage duct 7 of Figure 3 furthermore ends in such a way that it is obliquely sectioned downstream, because the nozzle end 18 is of asymmetrical construction.

In Figure 4 only the axis "x" of the passage duct 7 is arranged inclined relative to the axis "y" of the valve cone 6. The passage duct 7

is, here again, obliquely sectioned on the outlet side. In Figure 5 the axis "x" of the passage duct 7 is inclined more strongly, whilst the duct 7 leads out at the cone surface 18 of the frustoconically constructed nozzle 17.

In Figure 6 the contour of the passage duct 7 is a hyperboloid of rotation, and in Figure 7 the passage duct 7 is of conical construction, so that in both cases, exiting fuel jets have no further wall contact after leaving the valve seat 5. The conical construction of the passage duct 7 may also be adopted optionally for the embodiments according to Figures 2 to 5.

CLAIMS

1. A fuel injection valve for a fuel-injected internal-combustion engine, having a pintle which is guided in a nozzle element, and has a conical seat surface cooperating with a valve seat formed by a valve cone in the nozzle element, the pintle lifting from the valve seat counter to the force of a spring and counter to the fuel flow direction, the pintle tip simultaneously opening at least one spray passage leading to the combustion space of the internal-combustion engine and the opening cross-section of which is controllable as a function of the pintle stroke, wherein the or each spray passage is arranged in a part of the valve cone located upstream of the valve seat and forms an angle with the envelope line of the valve cone, and a duct located downstream of the valve cone is constructed as a passage duct of large cross-section, through which fuel is delivered unthrottled into the combustion space.

2. A fuel injection valve according to Claim 1, wherein the or each spray passage is formed as a groove in an insert element resting immovably on the valve cone of the nozzle element, said insert element having an upper cylindrical element part with feed ducts which are adjoined by the or each respective spray passage located in the lower conically constructed element part.

3. A fuel injection valve according to Claim 1 or Claim 2, wherein the axis of the passage duct is arranged to be offset relative to the axis of the valve cone and the passage duct opens at the nozzle end which is of plane construction.

4. A fuel injection valve according to Claim 1 or Claim 2, wherein the axis of the passage duct is arranged to be offset relative to the axis of the valve cone and the nozzle end of the nozzle element is formed as an asymmetrical conical construction, the passage duct opening at the larger cone surface of the nozzle end.

5. A fuel injection valve according to Claim 1 or Claim 2, wherein the axis of the passage duct is arranged to be inclined relative to the axis of the valve cone and the passage duct opens out at the nozzle end which is of plane construction.

6. A fuel injection valve according to Claim 1 or Claim 2, wherein the axis of the passage duct is arranged to be inclined relative to the axis of the valve cone and the passage duct opens at the cone surface of the nozzle end which is frustoconically constructed.

7. A fuel injection valve according to Claim 1 or Claim 2, wherein the contour of the wall of the passage duct is a hyperboloid of rotation so that emergent fuel jets have no further duct wall contact after leaving the valve seat.

8. A fuel injection valve according to any one of the preceding claims, wherein the passage duct is of conical construction.

9. A fuel injection nozzle for an internal-combustion engine substantially as hereinbefore described and with reference to Figure 1, or Figure 1 modified as shown in any one of Figures 2 to 7 of the accompanying drawings.

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